

PLASMA CLEANER

USER'S MANUAL FOR THE EXPANDED PLASMA CLEANER
PDC-002 (230V)
(AND OPTIONAL PLASMAFLO)





DECLARATION OF CONFORMITY



Harrick Plasma, Inc. hereby declares that the product listed is in conformity with the requirements and provisions of the following European Union CE directives and their respective standards.

EMC Directive:

89/336/EEC

Generic Emissions Standard:

EN 61000-6-4:2001

Product Specific Emissions:

EN 55011 Group 2 Class A

Generic Immunity Standard:

EN 61000-6-2: 2001

Immunity:

EN 61000-4-2

Electrostatic Discharge

EN 61000-4-3

Radiated Susceptibility

EN 61000-4-4

Electrical Fast Transient/Burst

EN 61000-4-5

Surge

EN 61000-4-6

Conducted Susceptibility

Low Voltage Directive:

98/68/EEC

Standard:

EN 60950

Safety of Information

Technology Equipment

Manufacturer's Name:

Harrick Plasma

Manufacturer's Address:

120 Brindley St.
Ithaca, NY 14850
USA

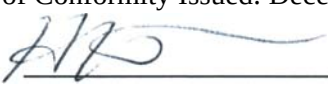
Products:

Expanded Plasma Cleaner / PlasmaFlo

Model Numbers:

PDC-002 / PDC-FMG-2

Declaration of Conformity Issued: December 20th, 2006

Signature: 

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Harrick Plasma, Inc.
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For further information, please contact Harrick Plasma or its authorized distributors:
See www.harrickplasma.com or e-mail info@harrickplasma.com.



ENVIRONMENTAL STATEMENT



Harrick Plasma, Inc. asserts the following statement regarding European Union directives governing disposal and restriction of hazardous substances in relation to the listed products.

Waste Electrical and Electronic Equipment (WEEE) Directive: 2002/96/EC

The products specified below comply with the WEEE Directive (2002/96/EC) marking requirement (shown above). The affixed product label indicates that you must not discard this electrical/electronic product in domestic household waste. To return unwanted products, please contact Harrick Plasma, Inc. With reference to the equipment categories in the WEEE directive Annex 1, Harrick Plasma has classified these products as "Monitoring and Control Instruments."

Restriction of Hazardous Substances (RoHS) Directive: 2002/95/EC

Harrick Plasma has classified the products specified below as "Monitoring and Control Instruments," an equipment category currently outside the scope of the RoHS Directive (2002/95/EC). Harrick Plasma is actively working toward transitioning to RoHS-compliant substances in future product iterations.

Environmental Statement Issued: December 20th, 2006

Manufacturer's Name:
Manufacturer's Address:

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Ph. (607) 272-5070
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Products:
Model Numbers:

Expanded Plasma Cleaner / PlasmaFlo
PDC-002 / PDC-FMG-2

For further information, please contact Harrick Plasma or its authorized distributors:
See www.harrickplasma.com or e-mail info@harrickplasma.com.

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SAFETY INFORMATION

The Plasma Cleaner is designed for safe and efficient operation when used properly and in accordance with this manual. Failure to observe the following precautions could result in serious personal injury:

- ⚠ The Plasma Cleaner is an electrical instrument; to avoid electric shock, please observe all standard precautions, such as not operating the device near water and operating the device at appropriate line voltage and frequency.
- ⚠ Do not remove cover plates or housing, except by a certified electronics technician.
- ⚠ Do not open the Plasma Cleaner front cover when the chamber is under vacuum.
- ⚠ Do not use the Plasma Cleaner near flammable materials.
- ⚠ Do not plug vacuum pumps whose input electrical current requirement exceeds 7 Amps into the Plasma Cleaner rear vacuum pump outlet.
- ⚠ With respect to vacuum pumps, please refer to the pump user's manual for specific precautions.
- ⚠ If oxygen is used as the process gas in concentrations near or above its flammability threshold, an oxygen service pump must be used.
- ⚠ If corrosive gases are used, make sure the seals and gas connection materials are compatible with the gas. Use a suitable vacuum pump to service corrosive gases.
- ⚠ If toxic gases or gases that ionize to toxic products or intermediates are used, the gases must be properly purged from the chamber prior to venting and the pump exhaust must be properly vented. For safe gas handling procedures specific to your process gas, contact your process gas supplier.

UNPACKING

Before installing the Plasma Cleaner make sure all the parts on the included check-off list are present. If any parts are missing or damaged, contact Harrick Plasma immediately.



GENERAL INFORMATION

TECHNICAL SUPPORT

For additional information please contact us between 9 a.m. and 5 p.m. EST:

(USA) 800-640-6380

(Intl) 607-272-5070

or e-mail your questions to:

info@harrickplasma.com

FEEDBACK

Your comments and suggestions are welcome. Please send them to:

Harrick Plasma

120 Brindley St.

Ithaca, NY 14850

(USA) 800-640-6380

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ABOUT THE PLASMA CLEANER

PRINCIPLE OF OPERATION

Plasma, the fourth state of matter, is a distinct processing medium for the treatment and modification of surfaces.

NATURE OF PLASMA

- Plasma is a partially ionized gas consisting of electrons, ions and neutral atoms or molecules.
- The plasma electrons are at a much higher temperature than the neutral gas species, typically around 10^4 K, although the plasma gas as a whole is at near ambient temperature.
- The plasma electron density is typically around 10^{10} cm^{-3} .

PLASMA FORMATION

- A radio frequency (RF) oscillating electric field is generated in the gas region through magnetic induction.
- At sufficiently low pressures the combined effect of the electric field acceleration of electrons and elastic scattering of the electrons with neutral atoms or field lines leads to heating of the electrons.
- When electrons gain kinetic energy in excess of the first ionization threshold in the neutral gas species, electron-neutral collisions lead to further ionization, yielding additional free electrons that are heated in turn.

PLASMA-SURFACE INTERACTION

- The energy of plasma electrons and ions is sufficient to ionize neutral atoms, break molecules apart to form reactive radical species, generate excited states in atoms or molecules, and locally heat the surface.
- Depending on the process gases and parameters, plasmas are capable of both mechanical work, through the ablative effect of kinetic transfer of electrons and ions with the surface, and chemical work, through the interaction of reactive radical species with the surface.
- In general, plasmas can interact with and modify a surface through several mechanisms: ablation, chemical etching, activation, deposition, and cross-linking.

ABOUT THE PLASMA CLEANER

TYPES OF PLASMA-SURFACE INTERACTIONS

ABLATION

- Plasma ablation involves the mechanical removal of surface contaminants by energetic electron and ion bombardment.
- Surface contamination layers (e.g. cutting oils, skin oils, mold releases) are typically comprised of weak C-H bonds.
- Ablation breaks down weak covalent bonds in polymeric contaminants through mechanical bombardment.
- Surface contaminants undergo repetitive chain scission until their molecular weight is sufficiently low for them to boil away in the vacuum.
- Ablation affects only the contaminant layers and the outermost molecular layers of the substrate material.
- Argon is often used for its high ablation efficiency and chemical inertness with the surface material.

CHEMICAL ETCHING

- Chemical etching involves the chemical reaction of surface organic contaminants with highly reactive free radicals in the plasma to form volatile byproducts that are released from the sample surface.
- By proper selection of the gas chemistry and mixture, various types of materials can be chemically etched. In addition, the material can be selectively etched with minimal etching of other materials on the sample surface.
- Chemical etching involves minimal physical damage or roughening of the sample surface.
- O₂ is often used for chemical etching of organic contaminants from sample surfaces.

ABOUT THE PLASMA CLEANER

TYPES OF PLASMA-SURFACE INTERACTIONS

ACTIVATION

- Plasma surface activation involves the creation of surface chemical functional groups through the use of plasma gases - such as oxygen, hydrogen, nitrogen and ammonia - which dissociate and react with the surface.
- In the case of polymers, surface activation involves the replacement of surface polymer groups with chemical groups from the plasma gas.
- The plasma breaks down weak surface bonds in the polymer and replaces them with highly reactive carbonyl, carboxyl, and hydroxyl groups.
- Such activation alters the chemical activity and characteristics of the surface, such as wetting and adhesion, yielding greatly enhanced adhesive strength and permanency.

DEPOSITION

- Plasma deposition involves the formation of a thin polymer coating at the substrate surface through polymerization of the process gas.
- The deposited thin coatings can possess various properties or physical characteristics, depending on the specific gas and process parameters selected.
- Such coatings exhibit a higher degree of cross-linking and much stronger adherence to the substrate in comparison to films derived from conventional polymerization.

CROSS-LINKING

- Cross-linking is the covalent bonding of polymer chains to form dense molecular networks.
- Plasma processing with inert gases can be used to cross-link polymers and produce a stronger and harder substrate surface.
- Under certain circumstances, cross-linking through plasma treatment can also lend additional wear or chemical resistance to a material.

ABOUT THE PLASMA CLEANER

PLASMA PROCESSING

In general, plasma processing proceeds as follows:

- The sample is placed in the reaction chamber and the chamber is evacuated.
- Process gas(es) are flowed into the chamber to sustain pressures from 300 to 1500 mTorr.
- The process gas is subjected to a MHz-range RF electromagnetic field, creating plasma at near ambient temperature.
- The type of interaction between the plasma and the sample surface depends on parameters such as the intensity and frequency of the RF power used to excite the plasma, the type of gas(es) that are ionized, the pressure and flow rate of the gas(es), the sample surface material, and the duration of the plasma process.
- Detailed guidance on plasma processing may be found in the subsequent *PLASMA PROCESSING* sections of this manual.

ABOUT THE PLASMA CLEANER

GETTING STARTED

Before starting, take a few moments to familiarize yourself with the Plasma Cleaner unit (Figure 1).

(A) • Front view



(B) • Back view

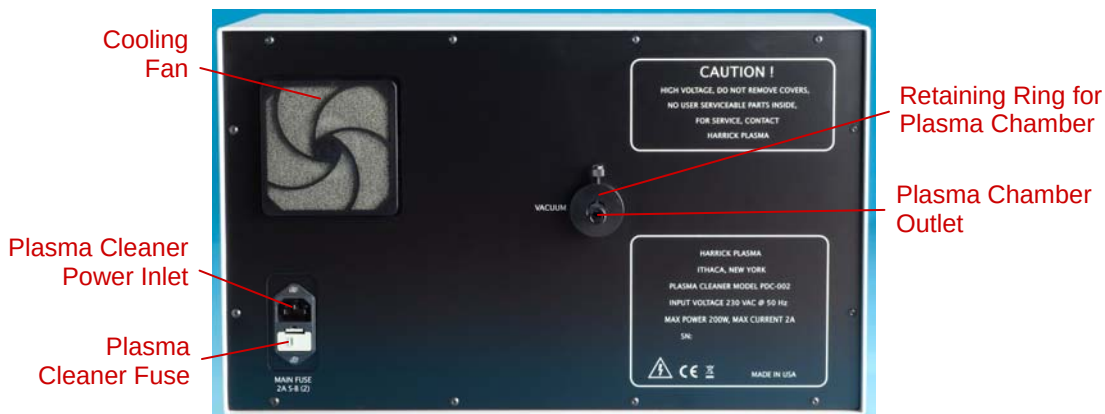


Figure 1 • Expanded Plasma Cleaner (230V)

NOTE: The expanded Plasma Cleaner PDC-002 is rated for 230V at 50Hz can accept line voltages of 220-240V at 50-60Hz.

ABOUT THE VACUUM PUMP

Use a vacuum pump with a minimum pumping speed of 1.4 m³/h and an ultimate total pressure of 200 mTorr or less.

SETTING UP A VACUUM PUMP FROM HARRICK PLASMA

If you have purchased a vacuum pump from Harrick Plasma, your pump should be accompanied by pump oil/fluid (if applicable), as well as a length of 1/2" inner diameter (ID) vacuum hose, hose clamps, inlet port adaptor, swing clamp, and centering ring to connect the pump to the Plasma Cleaner (Figure 2).

To set up the vacuum pump for use with the Plasma Cleaner (an Edwards XDS-5 dry pump is used as an example pump below):

- If applicable, fill the vacuum pump with the appropriate pump oil or fluid. Refer to the pump manual for instructions and oil/fluid capacity. Note that Fomblin-prepared pumps for oxygen service require Fomblin fluid, not pump oil.
- Place the centering ring on top of the inlet port of the vacuum pump (Figure 3A).
- Place the inlet port adaptor on top of the centering ring (Figure 3B).
- Wrap the swing clamp around the inlet port adaptor and centering ring. Tighten the swing clamp using the wing nut (Figure 3C).
- Connect the vacuum hose to the inlet port adaptor on the pump. Tighten a hose clamp over the end of the hose (Figure 3D).
- We recommend that the pump exhaust from the outlet port be properly vented, either by conducting the pump outlet exhaust to an exhaust hood through a vacuum hose or attaching an oil mist filter to the outlet port.

ABOUT THE VACUUM PUMP

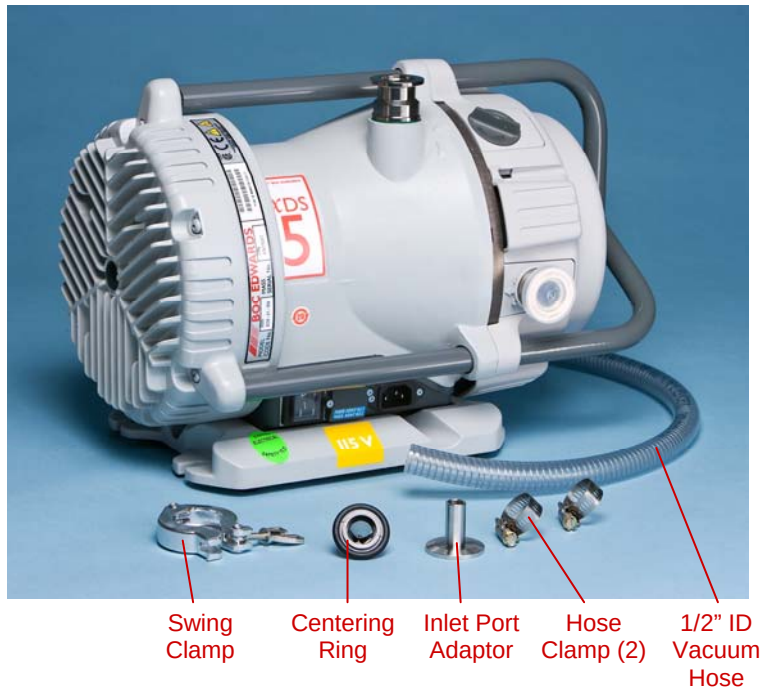


Figure 2 • Example of Vacuum Pump and Accessories

ABOUT THE VACUUM PUMP

(A) • Centering ring on the inlet port



(B) • Adaptor on the inlet port



(C) • Swing clamp around inlet port adaptor



(D) • Attach vacuum hose



Figure 3 • Setting Up the Vacuum Pump

ABOUT THE VACUUM PUMP

SETTING UP YOUR OWN VACUUM PUMP

If you are using your own vacuum pump, refer to your pump manufacturer for appropriate parts and accessories required for connecting the pump to the Plasma Cleaner. Below are guidelines to set up the vacuum pump for use with the Plasma Cleaner (see also the previous section *SETTING UP A VACUUM PUMP FROM HARRICK PLASMA* as an example):

- If applicable, make sure the vacuum pump is filled with the appropriate pump oil or fluid. Refer to the pump manual for instructions and oil/fluid capacity.
- To connect the vacuum pump to the plasma chamber outlet at the back of the Plasma Cleaner, use 1/2" inner diameter (ID) flexible vacuum hose with hose clamps tightened at both ends.
- To connect the vacuum hose to the inlet port of your vacuum pump, use a 1/2" outer diameter (OD) inlet port adaptor with the appropriate centering ring and swing clamp to tighten and seal to the inlet port.
- We recommend that the pump exhaust from the outlet port be properly vented, by either conducting the pump outlet exhaust to an exhaust hood through a vacuum hose or attaching an oil mist filter to the outlet port.

PROCESSING WITH ROOM AIR

SETUP

See *ABOUT THE VACUUM PUMP* for instructions to set up the vacuum pump for use with the Plasma Cleaner.

NOTE: *When connecting NPT tapered threads, always wrap the thread with PTFE (Teflon) tape to ensure a good seal and lubrication. Remove any debris or residual tape on the internal and external threads before wrapping with new tape and reconnecting. Wrap the tape in the direction counter to the screw direction. TIGHTEN ALL THREADED CONNECTIONS WITH A WRENCH.*

In preparation for setting up the Plasma Cleaner for operating with room air, refer to Figure 1 for identification of parts of the Plasma Cleaner, Figure 4 for valve assembly installation and Figure 5 for a schematic of the assembled system:

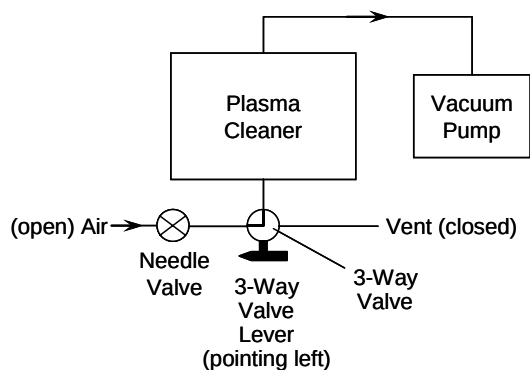
- Connect the needle valve/3-way valve to the Plasma Cleaner front door (Figure 4).
- Connect the plasma chamber outlet at the back of the Plasma Cleaner (Figure 1B) to the vacuum pump using 1/2" ID vacuum hose. Tighten hose clamps over the hose at each end.
- Plug one end of the Plasma Cleaner power cord into the power inlet on the back of the Plasma Cleaner and the other end into an electrical outlet.
- Plug the vacuum pump power cord into an electrical outlet.



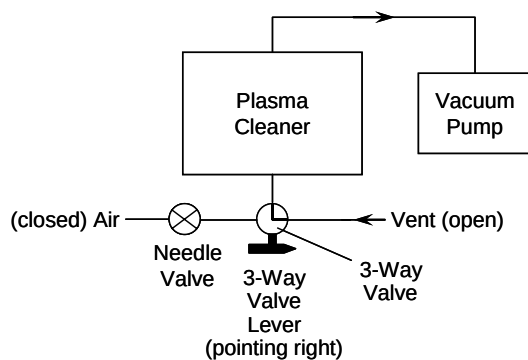
Figure 4 • Connecting the Needle Valve/3-Way Valve to the Plasma Cleaner Front Door

PROCESSING WITH ROOM AIR

(A) • To process gas (air)



(B) • To vent



(C) • 3-way valve closed

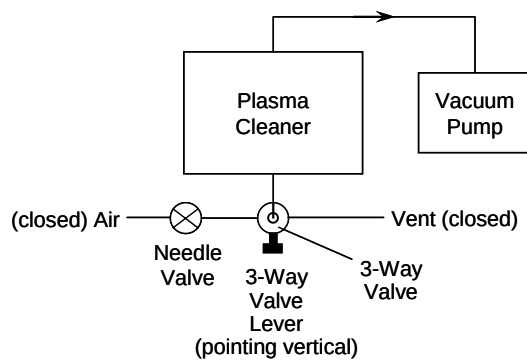


Figure 5 • Setup for Operating with Room Air

OPERATION**CAUTION:**

Following completion of processing, the Plasma Cleaner main power should be turned off in order to prevent overheating and possible damage to the Plasma Cleaner.

NOTE: *If the Plasma Cleaner is intended to be repeatedly used with no change to the process settings (as in the case of a single user), it is recommended for process repeatability to leave the needle valve open and fixed to the desired setting. Instead, use only the 3-way valve to switch between bleeding in air, isolating the plasma chamber, and venting (Figure 5).*

If the process settings of the Plasma Cleaner may vary with each use (as in the case of multiple users), it is recommended to close the needle valve at the end of each use as the default setting.

EVACUATING THE CHAMBER

- Put the sample in the Plasma Cleaner chamber.
- Check that the 3-way valve is closed (lever is in the vertical position, Figure 5C).
- Closed the front door and hold the door against the plasma chamber.
- Turn on the vacuum pump. The vacuum will hold the front door closed. It will take a few minutes to evacuate the air in the chamber.

BLEEDING IN AIR

- Open the 3-way valve to room air (lever points to the needle valve, Figure 5A).
- Slightly open the needle valve (1/8 of a turn or less) and allow the air to enter the Plasma Cleaner chamber.

GENERATING PLASMA

- Turn on the Plasma Cleaner main power.
- Select the appropriate RF power level (refer to the following *NOTE* on the next page).
- Look through the window of the Plasma Cleaner and wait until a glow is observed. For air, the plasma glow discharge should be purple-pink in color.
- Adjust the needle valve slightly until the plasma intensity is visibly maximized. This broadly corresponds to optimal plasma generation conditions.

PROCESSING WITH ROOM AIR

NOTE: *By selecting the process pressure, plasma energy (RF power), and processing duration, the nature and extent of the surface interactions can be tailored for your application.*

For optimal plasma uniformity, the RF power level should be set to MED or HI. Process pressures of 1000-1300 mTorr and process times of 1-3 minutes are good process parameter initial values. Optimal process parameter values will depend on the sample material and intended application. Some experimentation may be required to determine these optimal values.

PLASMA PROCESSING

- Process the sample for the desired duration.
- At the end of the process, set the RF power level to OFF.
- Turn off the Plasma Cleaner main power.

VENTING THE CHAMBER

- Turn off the vacuum pump.
- Slowly open the 3-way valve to vent (lever points to vent flow, Figure 5B).
- Once atmospheric pressure is reached, open the front door.
- Close the 3-way valve (lever is in the vertical position, Figure 5C).
- Take out the sample.

**CAUTION:**

If the Plasma Cleaner is not vented immediately, oil may backstream from the vacuum pump and contaminate the system. We recommend the use of a vacuum pump with an anti suck back feature, such as that optionally provided by Harrick Plasma. Do not open the front door when the chamber is under vacuum since this will damage the glass chamber.

SETUP

See *ABOUT THE VACUUM PUMP* for instructions to set up the vacuum pump for use with the Plasma Cleaner.

PURGE GAS LINE(S) PRIOR TO INSTALLATION

All gas lines to be connected to the Plasma Cleaner should be purged of any dust or residual contamination prior to installation.

NOTE: *When connecting NPT tapered threads, always wrap the thread with PTFE (Teflon) tape to ensure a good seal and lubrication. Remove any debris or residual tape on the internal and external threads before wrapping with new tape and reconnecting. Wrap the tape in the direction counter to the screw direction. TIGHTEN ALL THREADED CONNECTIONS WITH A WRENCH.*

In preparation for setting up the Plasma Cleaner for operating with process gas, refer to Figure 1 for identification of parts of the Plasma Cleaner, Figure 4 for valve assembly installation and Figure 6 for a schematic of the assembled system:

- Connect the needle valve/3-way valve to the front door (Figure 4).
- Attach an appropriate pressure regulator to the process gas cylinder. Use a regulator that is compatible with the process gas and that has the same connection size as on the gas cylinder. We recommend using regulated pressures of 5-10 psig. For added safety, include an isolation valve at the regulator output.
- Wrap the threads on the open end of the needle valve with Teflon tape. Connect the pressure regulator output to the needle valve through appropriate adaptors and tubing. The needle valve has 1/8" NPT fittings.
- Connect the plasma chamber outlet at the back of the Plasma Cleaner (Figure 1B) to the vacuum pump using 1/2" ID vacuum hose. Tighten hose clamps over the hose at each end.
- Plug one end of the Plasma Cleaner power cord into the power inlet on the back of the Plasma Cleaner and the other end into an electrical outlet.
- Plug the vacuum pump power cord into an electrical outlet.

NOTE: *To more precisely control the process gas flowrate and monitor pressure, we recommend using the optional PlasmaFlo (Figure 7).*

**CAUTION:**

For processing with pure oxygen, make sure that you use an oxygen compatible vacuum pump. The optional Harrick Plasma oil-based vacuum pumps are NOT oxygen compatible. The hydrocarbon pump oil mist can react with the concentrated oxygen to produce a potentially explosive combination. We do offer oxygen service pumps for use with oxygen process gas; please inquire with Harrick Plasma.

**CAUTION:**

If you are working with highly reactive or corrosive gases, be sure that the seals and gas connection materials of the Plasma Cleaner and vacuum pump are compatible with the gas(es). Use a suitable vacuum pump to service corrosive gases. It may be necessary to use different materials to avoid reaction with the process gas. Please contact Harrick Plasma to determine materials compatibility with your process gas(es).

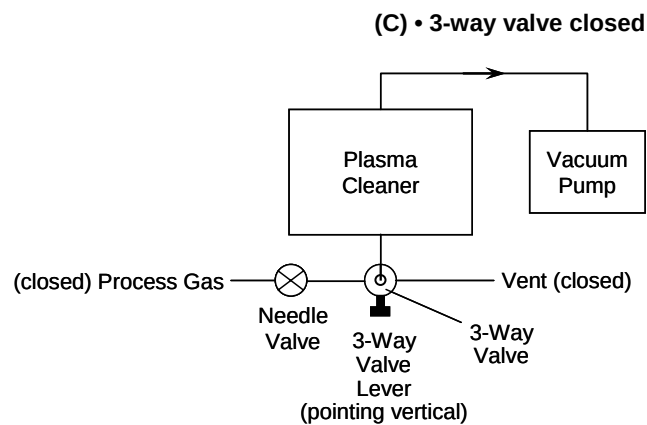
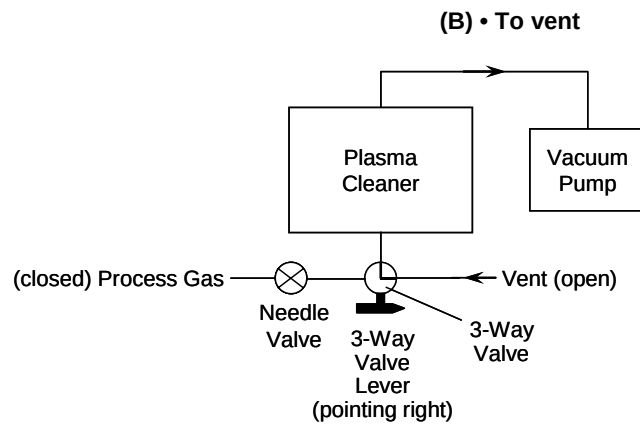
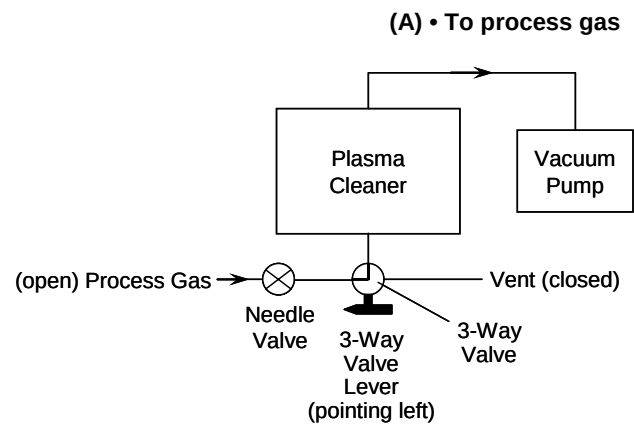


Figure 6 • Setup for Operating with Process Gas

OPERATION**CAUTION:**

Following completion of processing, the Plasma Cleaner main power should be turned off in order to prevent overheating and possible damage to the Plasma Cleaner.

**CAUTION:**

If you are working with toxic or highly reactive gases, the gases must be handled with extreme caution. To avoid releasing toxic or highly reactive gases into the ambient environment, it is recommended to run several purge cycles (flood the chamber with an inert gas (e.g. N₂ or Ar) and allow it to pump out) to ensure the toxic and highly reactive gases are properly evacuated from the gas line and chamber prior to venting. The pump exhaust must also be properly vented.

See CONFIGURATION OPTIONS: PURGING WITH INERT GAS for general guidelines to set up the Plasma Cleaner to purge with inert gas. For safe gas handling procedures specific to your process gas, contact your process gas supplier.

NOTE: *If the Plasma Cleaner is intended to be repeatedly used with no change to the process settings (as in the case of a single user), it is recommended for process repeatability to leave the needle valve open and fixed to the desired setting. Instead, use only the 3-way valve to switch between bleeding in gas, isolating the plasma chamber, and venting (Figure 6).*

If the process settings of the Plasma Cleaner may vary with each use (as in the case of multiple users), it is recommended to close the needle valve at the end of each use as the default setting.

EVACUATING THE CHAMBER

- Put the sample in the Plasma Cleaner chamber.
- Check that the 3-way valve is closed (lever is in the vertical position, Figure 6C).
- Closed the front door and hold the door against the plasma chamber.
- Turn on the vacuum pump. The vacuum will hold the front door closed. It will take a few minutes to evacuate the air in the chamber.

PROCESSING WITH GAS

BLEEDING IN PROCESS GAS

- Open the process gas cylinder valve (and isolation valve at regulator output) and adjust the regulator pressure to 5-10 psig.
- Open the 3-way valve to process gas (lever points to the needle valve, Figure 6A).
- Slightly open the needle valve (1/8 of a turn or less) and allow the gas to flow for 30-60 seconds.

GENERATING PLASMA

- Turn on the Plasma Cleaner main power.
- Select the appropriate RF power level (refer to the following *NOTE* below).
- Look through the window of the Plasma Cleaner and wait until a glow is observed. This indicates that plasma has been generated.
- Adjust the needle valve slightly until the plasma intensity is visibly maximized. This broadly corresponds to optimal plasma generation conditions.

NOTE: *By selecting the process gas (or gas mixture), process pressure, plasma energy (RF power), and processing duration, the nature and extent of the surface interactions can be tailored for your application.*

For optimal plasma uniformity, the RF power level should be set to MED or HI. Process pressures of 1000-1300 mTorr and process times of 1-3 minutes are good process parameter initial values. Optimal process parameter values will depend on the sample material and intended application. Some experimentation may be required to determine these optimal values.

PLASMA PROCESSING

- Process the sample for the desired duration.
- At the end of the process, set the RF power level to OFF.
- Turn off the Plasma Cleaner main power.
- Close the process gas cylinder valve (and isolation valve at regulator output).
- Allow 1-3 minutes for the vacuum pump to pump out any residual process gas from the chamber.
- Close the needle valve.
- Close the 3-way valve (lever is in the vertical position, Figure 6C).

**CAUTION:**

If you are working with toxic or highly reactive gases, the gases must be handled with extreme caution. To avoid releasing toxic or highly reactive gases into the ambient environment, it is recommended to run several purge cycles (flood the chamber with an inert gas (e.g. N₂ or Ar) and allow it to pump out) to ensure the toxic or highly reactive gases are properly evacuated from the gas line and chamber prior to venting. The pump exhaust must also be properly vented.

See CONFIGURATION OPTIONS: PURGING WITH INERT GAS for general guidelines to set up the Plasma Cleaner to purge with inert gas. For safe gas handling procedures specific to your process gas, contact your process gas supplier.

VENTING THE CHAMBER

- Turn off the vacuum pump.
- Slowly open the 3-way valve to vent (lever points to the vent flow, Figure 6B).
- Once atmospheric pressure is reached, open the front door.
- Close the 3-way valve (lever is in the vertical position, Figure 6C).
- Take out the sample.

**CAUTION:**

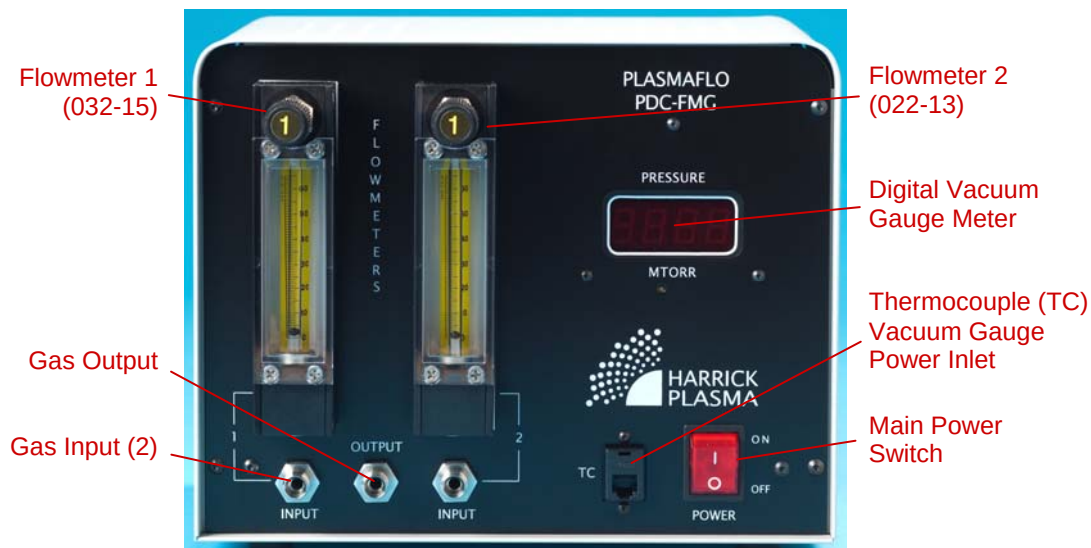
If the Plasma Cleaner is not vented immediately, oil may backstream from the vacuum pump and contaminate the system. We recommend the use of a vacuum pump with an anti suck back feature, such as that optionally provided by Harrick Plasma. Do not open the front door when the chamber is under vacuum since this will damage the glass chamber.

USING THE OPTIONAL PLASMAFLO

GETTING READY

Before starting, take a few moments to familiarize yourself with the PlasmaFlo (Figure 7) and PlasmaFlo accessories (Figure 8).

(A) • Front view



(B) • Back view

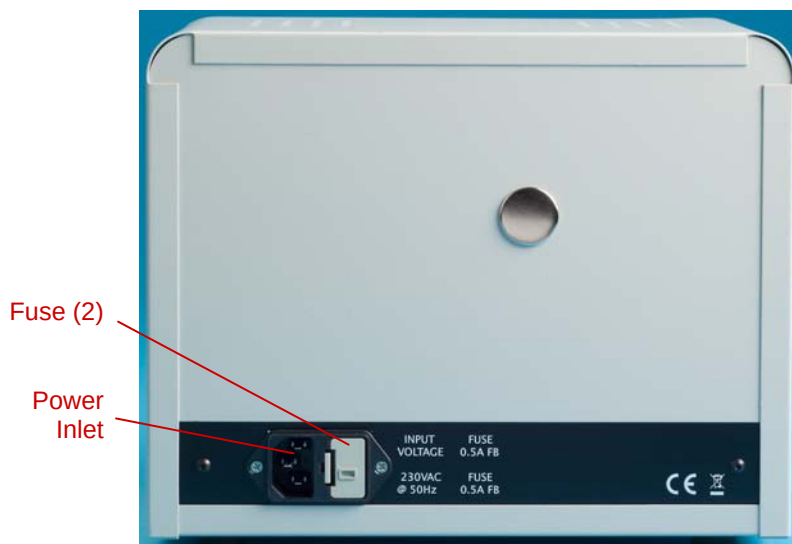


Figure 7 • PlasmaFlo (230V)

NOTE: The PlasmaFlo PDC-FMG-2 is rated for 230V at 50Hz but can accept line voltages of 220-240V at 50-60Hz.

USING THE OPTIONAL PLASMAFLO

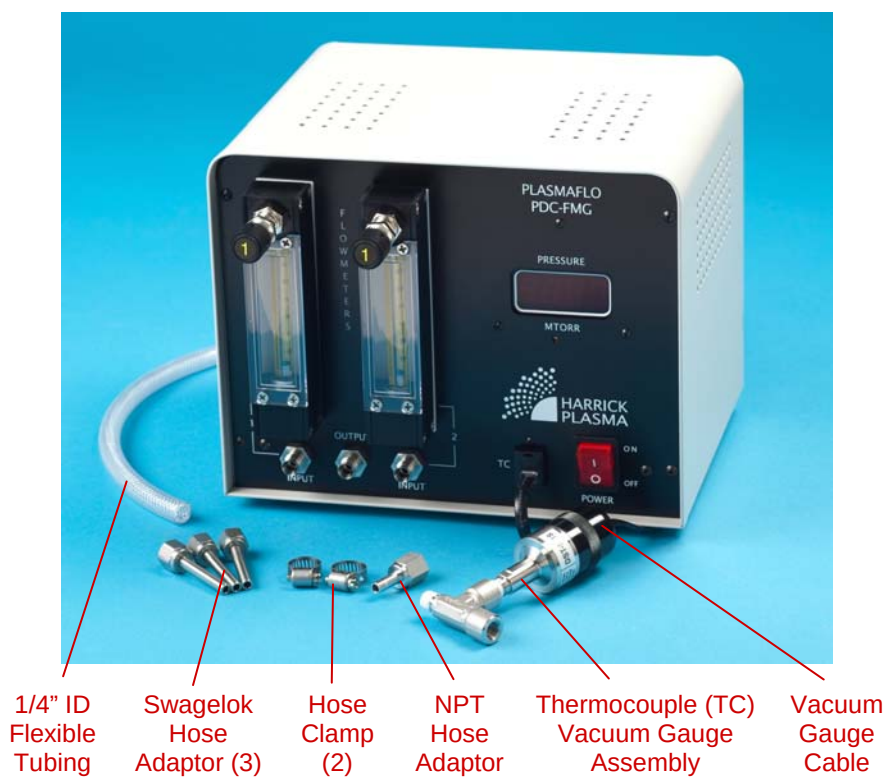


Figure 8 • PlasmaFlo and Accessories



USING THE OPTIONAL PLASMAFLO

SETUP

See *ABOUT THE VACUUM PUMP* for instructions to set up the vacuum pump for use with the Plasma Cleaner.

PRESSURE REGULATOR SELECTION

Use a pressure regulator that is compatible with the process gas and that has the same connection size as on the gas cylinder. For added safety, include an isolation valve at the regulator output.

A two-stage regulator is able to provide more stable regulated pressures under conditions where downstream pressures (at the plasma chamber) may fluctuate and is recommended over a single-stage regulator.

For process gas delivery, we recommend using regulated pressures of 10 psig to enable use of the correlated flowrate tables provided for each flowmeter in *APPENDIX A*. If other regulated pressures are desired, please inquire with Harrick Plasma.

PURGE GAS LINE(S) PRIOR TO INSTALLATION

All gas lines to be connected to the flowmeter(s) should be purged of any dust or residual contamination prior to installation. All flowmeters have a built-in filter at the inlet.

To prevent the float from potentially getting stuck along the flowtube of the flowmeter(s), use only dry, clean gas.

NOTE: *When connecting NPT tapered threads, always wrap the thread with PTFE (Teflon) tape to ensure a good seal and lubrication. Remove any debris or residual tape on the internal and external threads before wrapping with new tape and reconnecting. Wrap the tape in the direction counter to the screw direction. TIGHTEN ALL THREADED CONNECTIONS WITH A WRENCH.*

In preparation for setting up the Plasma Cleaner and PlasmaFlo for operating with process gas(es), refer to Figure 1 for identification of parts of the Plasma Cleaner, Figure 7 and 8 for identification of the PlasmaFlo and accessories, Figure 9 for valve/TC vacuum gauge configuration on the front door and Figure 10 for a schematic of the assembled system:

- Connect the needle valve/3-way valve assembly to the thermocouple (TC) vacuum gauge assembly. Tighten with a wrench.
- Connect the needle valve/3-way valve/TC vacuum gauge assembly to the Plasma Cleaner front door. Tighten with a wrench. The final configuration of the valves and TC vacuum gauge assembly on the front door is shown in Figure 9.

USING THE OPTIONAL PLASMAFLO

SETUP (continued)

- To connect the PlasmaFlo gas output to the needle valve using the supplied hose adaptors and 1/4" ID flexible tubing: connect the Swagelok hose adaptor to the PlasmaFlo gas output (tighten with a wrench). Attach one end of the flexible tubing to the PlasmaFlo gas output and the other end of the tubing to the NPT hose adaptor on the needle valve. Tighten hose clamps over each end of the tubing.

OR

Alternatively, you may use other types of tubing and adaptors of your choice to connect the PlasmaFlo gas output to the needle valve. The needle valve has 1/8" NPT fittings and the PlasmaFlo gas output has 1/4" Swagelok fittings.

- Attach appropriate pressure regulator(s) to the process gas cylinder(s). See *PRESSURE REGULATOR SELECTION* above.
- To connect the gas cylinder pressure regulator to the PlasmaFlo gas input(s) using the supplied Swagelok hose adaptors: connect the two (2) Swagelok hose adaptors to the PlasmaFlo gas input(s) (tighten with a wrench). Use appropriate hose adaptors and 1/4" ID flexible tubing to connect the pressure regulator output to the PlasmaFlo gas input. Tighten hose clamps over each end of the tubing.

OR

Alternatively, you may use other types of tubing and adaptors of your choice to connect the pressure regulator output(s) to the PlasmaFlo gas input(s). The PlasmaFlo gas inputs have 1/4" Swagelok fittings.

- Connect the supplied vacuum gauge cable between the TC vacuum gauge and the thermocouple vacuum gauge power inlet (TC) on the PlasmaFlo front panel.
- Connect the plasma chamber outlet at the back of the Plasma Cleaner (Figure 1B) to the vacuum pump using 1/2" ID vacuum hose. Tighten hose clamps over the hose at each end.
- Plug the vacuum pump power cord into an electrical outlet.
- Plug one end of the Plasma Cleaner power cord into the power inlet on the back of the Plasma Cleaner and the other end into an electrical outlet.
- Plug one end of the PlasmaFlo power cord into the power inlet on the back of the PlasmaFlo and the other end into an electrical outlet.

USING THE OPTIONAL PLASMAFLO

**CAUTION:**

For processing with pure oxygen, make sure that you use an oxygen compatible vacuum pump. The optional Harrick Plasma oil-based vacuum pumps are NOT oxygen compatible. The hydrocarbon pump oil mist can react with the concentrated oxygen to produce a potentially explosive combination. We do offer oxygen service pumps for use with oxygen process gas; please inquire with Harrick Plasma.

**CAUTION:**

If you are working with highly reactive or corrosive gases, be sure that the seals and gas connection materials of the Plasma Cleaner and vacuum pump are compatible with the gas(es). Use a suitable vacuum pump to service corrosive gases. It may be necessary to use different materials to avoid reaction with the process gas. Please contact Harrick Plasma to determine materials compatibility with your process gas(es).



Figure 9 • Final Configuration of the Needle Valve, 3-Way Valve, and TC Vacuum Gauge on the Plasma Cleaner Front Door When Using the Optional PlasmaFlo

USING THE OPTIONAL PLASMAFLO

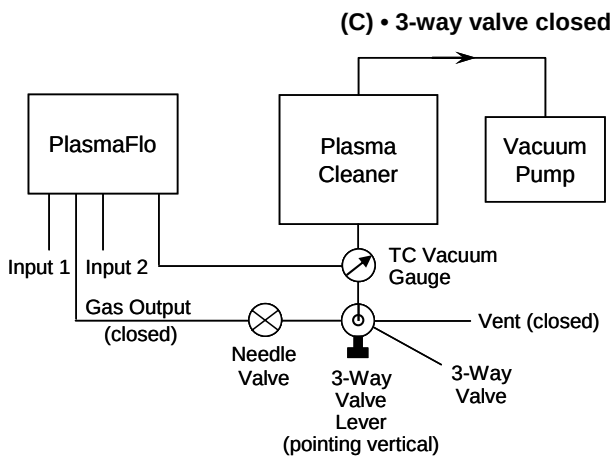
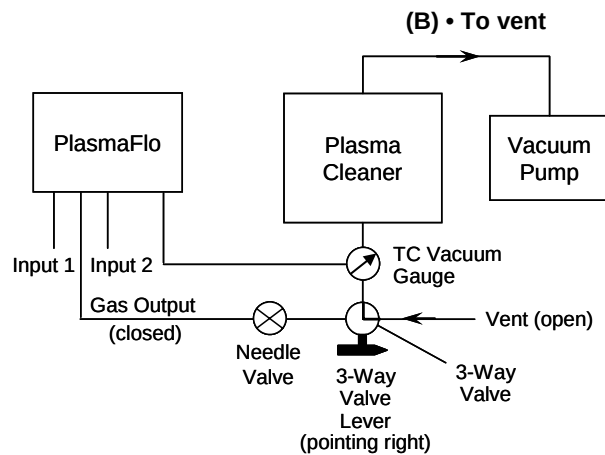
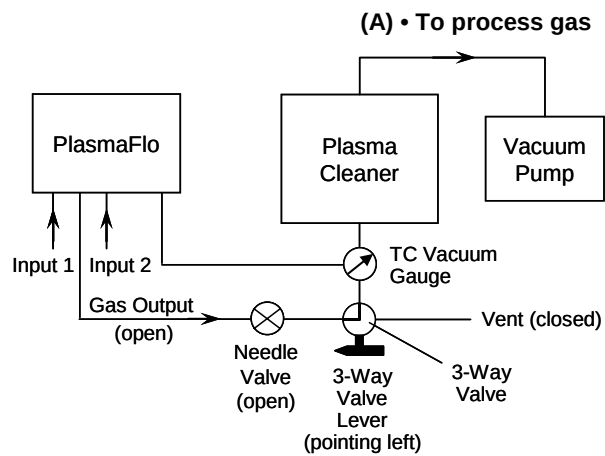


Figure 10 • Setup for Operating with Process Gas and PlasmaFlo

OPERATION**CAUTION:**

Following completion of processing, the Plasma Cleaner main power should be turned off in order to prevent overheating and possible damage to the Plasma Cleaner.

USING THE FLOWMETERS

Flowmeters with a 65mm reference scale, rather than a direct-read scale, are provided to enable use with a broad range of gases.

Correlated flowrate tables that convert the millimeter (mm) scale reading to an actual flowrate (mL/min) are available for the most common process gases used with the Plasma Cleaner (air, Ar, N₂, O₂), metered at a regulated pressure of 10 psig. **Please note that Flowmeter 1 (032-15) and Flowmeter 2 (022-13) have different flow capacities.** See APPENDIX A for flowrate tables for each flowmeter.

Correlated flowrate tables for other process gases or other regulated pressures can be made available. Please inquire with Harrick Plasma.

Before opening the gas cylinder valve and isolation valve to introduce process gas into the plasma system, make sure the flowmeter valves are closed to avoid the sudden rise of the float and having the float hit the top of the flowtube.

WHEN CLOSING THE FLOWMETER(S), DO NOT OVERTIGHTEN THE FLOWMETER VALVES.

**CAUTION:**

If you are working with toxic or highly reactive gases, the gases must be handled with extreme caution. To avoid releasing toxic or highly reactive gases into the ambient environment, it is recommended to run several purge cycles (flood the chamber with an inert gas (e.g. N₂ or Ar) and allow it to pump out) to ensure the toxic or highly reactive gases are properly evacuated from the gas line and chamber prior to venting. The pump exhaust must also be properly vented.

See CONFIGURATION OPTIONS: PURGING WITH INERT GAS for general guidelines to set up the Plasma Cleaner to purge with inert gas. For safe gas handling procedures specific to your process gas, contact your process gas supplier.

USING THE OPTIONAL PLASMAFLO

EVACUATING THE CHAMBER

- Put the sample in the Plasma Cleaner chamber.
- Turn on the PlasmaFlo main power.
- Check that the 3-way valve is closed (lever is in the vertical position, Figure 10C).
- On the PlasmaFlo, check that the flowmeter valves are closed.
- Close the Plasma Cleaner front door and hold the door against the plasma chamber.
- Turn on the vacuum pump. The vacuum pump will hold the front door closed. The pressure, as indicated by the vacuum gauge meter, should begin to decrease.
- Pump down the chamber to ~200 mTorr (or to the desired base pressure) and allow the pressure to equilibrate prior to flowing in process gas(es).

BLEEDING IN PROCESS GAS(ES)

- Open the 3-way valve to process gas (lever points to the needle valve, Figure 10A).
- Open the needle valve. The vacuum pressure will initially increase but will gradually decrease towards the starting base pressure as the residual air in the gas line is evacuated.
- Open the process gas cylinder valve(s) and adjust the regulator pressure to 10 psig. Slowly open the regulator isolation valve. The floats in the flowmeter flowtube may rise slightly due to the sudden pressure increase upon opening the regulator isolation valve.
- Slowly open the flowmeter valve(s) and set the desired flowrate or set the flow level to obtain the desired pressure. Read off the millimeter (mm) reference scale reading, located on the flowtube, from the center of the float. See *APPENDIX A* to convert the mm scale reading to the actual flowrate (mL/min). The float position may deviate slightly after setting the flow level due to relaxation of the flowmeter valve as it equilibrates to its new position. Allow a few minutes for the pressure to stabilize after setting the gas flowrate.

GENERATING PLASMA

- Turn on the Plasma Cleaner main power.
- Select the appropriate RF power level (refer to the following *NOTE* on the next page).
- Look through the window of the Plasma Cleaner and wait until a glow discharge is observed. This indicates that plasma has been generated. Plasma that is visibly maximized broadly corresponds to optimal plasma generation conditions.

USING THE OPTIONAL PLASMAFLO

NOTE: *By selecting the process gas (or gas mixture), process pressure, plasma energy (RF power), and processing duration, the nature and extent of the surface interactions can be tailored for your application.*

For optimal plasma uniformity, the RF power level should be set to MED or HI. Process pressures of 1000-1300 mTorr and process times of 1-3 minutes are good process parameter initial values. Optimal process parameter values will depend on the sample material and intended application. Some experimentation may be required to determine these optimal values.

PLASMA PROCESSING

- Process the sample for the desired duration.
- At the end of the process, set the RF power level to OFF.
- Turn off the Plasma Cleaner main power.
- Close the process gas cylinder valve(s) and isolation valve(s).
- Allow 1-3 minutes for the system to pump out any residual process gas(es) from the chamber.
- Close the flowmeter valve(s).
- Close the needle valve and 3-way valve (lever is in the vertical position, Figure 10C).



CAUTION:

If you are working with toxic or highly reactive gases, the gases must be handled with extreme caution. To avoid releasing toxic or highly reactive gases into the ambient environment, it is recommended to run several purge cycles (flood the chamber with an inert gas (e.g. N₂ or Ar) and allow it to pump out) to ensure the toxic or highly reactive gases are properly evacuated from the gas line and chamber prior to venting. The pump exhaust must also be properly vented.

See CONFIGURATION OPTIONS: PURGING WITH INERT GAS for general guidelines to set up the Plasma Cleaner to purge with inert gas. For safe gas handling procedures specific to your process gas, contact your process gas supplier.

USING THE OPTIONAL PLASMAFLO

VENTING THE CHAMBER

- Turn off the vacuum pump.
- Slowly open the 3-way valve to vent (lever points to the vent flow, Figure 10B).
- Once atmospheric pressure is reached, open the front door.
- Close the 3-way valve (lever is in the vertical position, Figure 10C).
- Turn off the PlasmaFlo main power.
- Remove the sample.

**CAUTION:**

If the Plasma Cleaner is not vented immediately, oil may backstream from the vacuum pump and contaminate the system. We recommend the use of a vacuum pump with an anti suck back feature, such as that optionally provided by Harrick Plasma. Do not open the front door when the chamber is under vacuum since this will damage the glass chamber.

PURGING WITH INERT GAS

If you are working with toxic or highly reactive gases, the gases must be handled with extreme caution. To avoid releasing toxic or highly reactive gases into the ambient environment, it is recommended to run several purge cycles (flood the chamber with an inert gas (e.g. N₂, Ar) and allow it to pump out) prior to venting to ensure the toxic or highly reactive gases are properly evacuated from the chamber. The pump exhaust must also be properly vented.

Note that the procedures outlined below are general guidelines for purging the plasma system with inert gas. For safe gas handling procedures specific to your process gas, please consult with your process gas supplier.

SETUP

The inert gas line should be connected immediately after the process gas regulator output to flush out as much of the process gas line as possible. A possible configuration for connecting the inert gas line to the process gas line in conjunction with the plasma system is shown in Figure 11 as an example. For safe gas handling equipment and procedures specific to your process gas, please further consult with your process gas supplier.

- Attach an appropriate pressure regulator (preferably one with an isolation valve at the regulator output) to the inert gas cylinder.
- Use appropriate tubing and adaptors to connect the inert gas regulator output to the process gas line as close to the process gas regulator as possible.

**PURGING WITH INERT GAS
AFTER PLASMA PROCESSING**

To purge the gas line and plasma chamber with inert gas after following the procedures in *PLASMA PROCESSING* (page 21 or page 32):

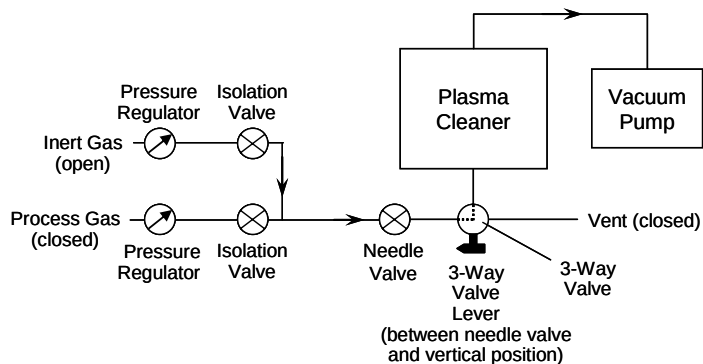
- Check that the process gas cylinder valve and isolation valve are closed.
- Check that the 3-way valve is in the closed position (lever is in the vertical direction, Figure 6C or 10C).
- If using the optional PlasmaFlo, check that the flowmeter valves are closed.
- Open the needle valve.
- Open the inert gas cylinder valve. Adjust the inert gas pressure regulator to 10 psig. Slowly open the regulator isolation valve.
- If using optional the PlasmaFlo, slowly open the flowmeter valve that is connected to the inert gas line to the highest flow capacity.

CONFIGURATION OPTIONS

PURGING WITH INERT GAS AFTER PLASMA PROCESSING (continued)

- Partially open the 3-way valve to inert gas (lever is intermediate to needle valve and vertical position, Figure 11). If using the optional PlasmaFlo, the pressure should quickly increase.
- Close the 3-way valve (lever is in the vertical position, Figure 6C or 10C). These steps should be performed quickly to avoid disturbing the sample or overloading the vacuum pump. If using the optional PlasmaFlo, the pressure should decrease back to a lower pressure.
- Repeat the previous 2 steps of quickly opening and closing the 3-way valve to inert gas flow. Repeat a third time. At the end of this procedure, the 3-way valve should be closed (lever is in the vertical position, Figure 6C or 10C).
- Close the inert gas cylinder valve and regulator isolation valve.
- Allow 1-3 minutes for the vacuum pump to evacuate any residual gas from the chamber.
- Close the flowmeter valve.
- If necessary, repeat the above steps with the second process gas.
- Close the needle valve.
- Turn off the vacuum pump.
- Slowly open the 3-way valve to vent (lever points to the vent flow, Figure 6B or 10B).
- Once atmospheric pressure is reached, open the front door.
- Close the 3-way valve (lever is in the vertical position, Figure 6C or 10C).
- Turn off the Plasma Cleaner main power and optional PlasmaFlo main power.
- Remove the sample.

(A) • Inert Gas Purge with Plasma Cleaner



(B) • Inert Gas Purge with Plasma Cleaner and Optional PlasmaFlo

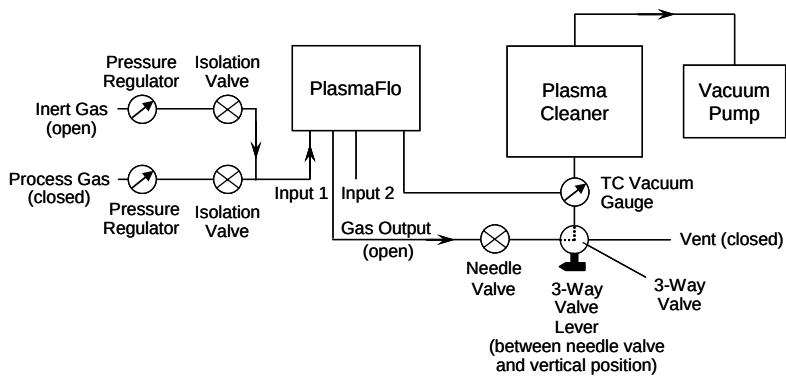


Figure 11 • A Possible Configuration for Inert Gas Purge in the Plasma System

**MAINTENANCE
REQUIREMENTS**

For most plasma cleaning and plasma processing applications, the Plasma Cleaner requires little or no maintenance. The vacuum pump does require routine servicing. Please review the pump manual to determine the maintenance requirements for the vacuum pump.

CLEANING THE CHAMBER

Some combinations of process gas(es) and sample materials may generate particulates and contaminants that can accumulate on the chamber wall. Over time, these contaminants may affect the plasma power and effectiveness of the plasma process. If a change to the plasma process or plasma intensity is detected, the chamber may require cleaning to remove these contaminants.

**CAUTION:**

Please take all safety precautions and use the appropriate personal protection equipment (e.g. gloves, goggles, etc.) when cleaning the plasma chamber with solvents or hazardous chemicals.

The plasma chamber is made of borosilicate glass (Pyrex) and may be cleaned using similar cleaning methods for standard laboratory glassware, such as:

- Soaking or wiping the plasma chamber surface with acetone or isopropyl alcohol.
- Cleaning the plasma chamber using a standard laboratory glassware cleaner (e.g. Alconox).

REPLACING THE CHAMBER

If standard laboratory glassware cleaning methods do not remove the contaminants and the contaminants are affecting the plasma process, the chamber may require replacement. See *APPENDIX B: OPTIONAL AND REPLACEMENT PARTS* to find the appropriate part number.

To replace the Plasma Cleaner chamber (Figure 12):

- Disconnect the vacuum hose on the plasma chamber outlet at the back of the Plasma Cleaner (Figure 12A).
- Loosen the thumbscrew of the retaining ring on the plasma chamber outlet (Figure 12B). Remove the retaining ring.
- Slide the old chamber out (Figure 12C).
- Slide the new chamber in.
- Slide the retaining ring onto the plasma chamber outlet and hand-tighten the thumbscrew.
- Reconnect the vacuum hose to the plasma chamber outlet. Tighten the hose clamp around the end of the tubing.

(A) • Disconnect the vacuum hose from the plasma chamber outlet



(B) • Loosen the thumbscrew of the retaining ring



(C) • Slide the old chamber out

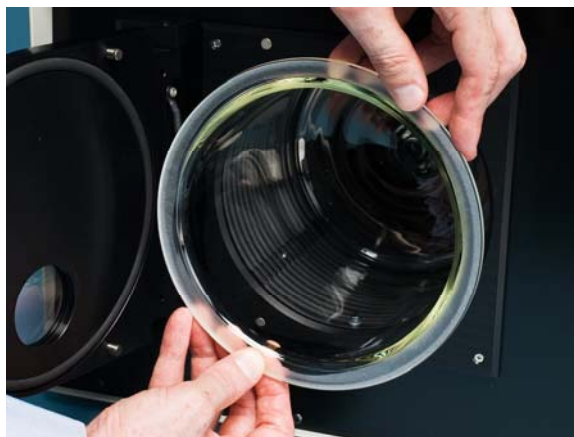


Figure 12 • Replacing the Plasma Chamber

**CLEANING THE PLASMA
CLEANER FRONT DOOR
AND O-RING**

To clean the Plasma Cleaner door and o-ring:

- Remove the o-ring from the Plasma Cleaner door (Figure 13).
- Wipe the interior of the Plasma Cleaner door with isopropyl alcohol.
- Visually inspect the o-ring. If the o-ring shows signs of degradation (e.g. surface is cracked or worn), replace the o-ring (see *APPENDIX B: OPTIONAL AND REPLACEMENT PARTS* to find the appropriate part number). If the o-ring appears in good condition, wipe the o-ring with isopropyl alcohol to remove any debris or contaminants on the surface.
- Reinsert the o-ring into the circular groove on the Plasma Cleaner door. Make sure the o-ring is properly seated in the groove.



Figure 13 • Removing the O-Ring on the Plasma Cleaner Front Door

REPLACING THE WINDOW AND WINDOW O-RING

To replace the Plasma Cleaner window (Figure 14):

- Remove the three (3) screws securing the Plasma Cleaner window (Figure 14A).
- Remove the retaining ring in front of the window (Figure 14B).
- Remove the window (Figure 14C).
- Remove the o-ring (Figure 14D) and visually inspect it. If the o-ring shows signs of degradation (e.g. surface is cracked or worn), replace the o-ring (see *APPENDIX B: OPTIONAL AND REPLACEMENT PARTS* to find the appropriate part number). If the o-ring appears in good condition, wipe the o-ring with isopropyl alcohol to remove any debris on the surface.
- Reinsert the o-ring into the circular groove. Make sure the o-ring is properly seated in the groove.
- Insert the new window.
- Reinsert the retaining ring.
- Secure the retaining ring with the three (3) screws. Tighten with a wrench.

(A) • Remove the three (3) screws



(B) • Remove the retaining ring



(C) • Remove the window



(D) • Remove the o-ring



Figure 14 • Replacing the Window on the Plasma Cleaner Front Door

**CHECKING AND
REPLACING THE FUSES**

- Remove the fuse holder on the back of the Plasma Cleaner (Figure 1B).
- Check the fuse either visually or using a digital multimeter:
If the fuse is in working condition, the metal wire inside the fuse should be intact and the digital multimeter should indicate an electrical short across the fuse (resistance of 1 ohm or less).
If the fuse is blown, the metal wire inside the fuse may be broken and the digital multimeter should indicate an electrical open across the fuse (resistance overload (OL)).
- Replace the blown fuse(s). Refer to the back of the Plasma Cleaner (Figure 1B) or *APPENDIX B: OPTIONAL AND REPLACEMENT PARTS* for specifications on the replacement fuse(s).
- Reinsert the fuse holder into the back of the Plasma Cleaner.

TROUBLESHOOTING

MALFUNCTION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Plasma fails to form in the chamber.	The electronics fails to deliver power to RF coil. The vacuum system fails to sufficiently evacuate the chamber.	Check the fuses in the back of the unit. Replace any blown fuses (refer to <i>MAINTENANCE: CHECKING AND REPLACING THE FUSES</i>). If plasma still does not form, test the electronics with the fluorescent bulb. Place the miniature fluorescent bulb supplied with the Plasma Cleaner into the chamber. Leave the door open and turn the RF power level to its three (3) settings, successively. If the bulb glows on all three RF power settings, the electronic system is functioning properly; proceed to the test of the vacuum system below. If the electronics test fails, contact Harrick Plasma. If you are using a vacuum pump not supplied by Harrick Plasma, make sure that your vacuum pump is capable of reaching an ultimate total pressure of 200 mTorr or less. Then check that the vacuum hose is properly attached, all hose clamps and gas line connections are properly tightened, the Plasma Cleaner door is properly seated, and the door o-ring is in place. The o-ring should be clean and free of defects. If you are still unable to form plasma following these test and corrective procedures, contact Harrick Plasma.
Plasma degrades in effectiveness of surface treatment.	Contaminants from previous use have deposited on the plasma chamber walls and door interior.	Plasma chamber and/or door requires cleaning. See <i>MAINTENANCE: CLEANING THE CHAMBER</i> and <i>MAINTENANCE: CLEANING THE PLASMA CLEANER DOOR AND O-RING</i> .

TROUBLESHOOTING

MALFUNCTION	POSSIBLE CAUSES	CORRECTIVE ACTIONS
Float becomes stuck along the flowtube of one of the PlasmaFlo flowmeters.	Dust/particulates or condensation in the flowtube is causing the float to stick.	The clearance (spacing) between the float and inner wall of the flowtube is very small (less than 0.5 mm) to achieve such low flowrates. Any dust, particulates, or condensation that may have formed from temperature fluctuations during shipping can cause the float to stick. To free the float: disconnect the gas lines at the PlasmaFlo gas input and output. Open the flowmeter valve fully, Blow clean, dry compressed air or inert gas through the PlasmaFlo gas input until the float moves freely along the flowtube. To prevent dust or condensation from accumulating in the flowtubes, use only dry, clean gas with the PlasmaFlo. If the float continues to stick, contact Harrick Plasma.



WARRANTY INFORMATION

DISCLAIMER

The Plasma Cleaner is designed for safe and efficient operation when used properly and in accordance with the instructions. Failure to observe the following precautions could result in serious personal injury: The Plasma Cleaner is an electrical instrument; to avoid electric shock, please observe all standard precautions, such as not operating the device near water and operating the device at appropriate line voltage and frequency. Do not remove cover plates or housing, except by certified electronics technician. Do not open the Plasma Cleaner door when the chamber is under vacuum. Do not use the Plasma Cleaner near flammable materials. Do not plug vacuum pumps whose input electrical current requirement exceeds 7 Amps into the Plasma Cleaner. With respect to vacuum pumps, please refer to the pump user's manual for specific precautions. In general, for oxygen process gas, an oxygen compatible pump should be used; in case of using toxic gases or gases that ionize to toxic products, an efficient pump exhaust filter should be used. Harrick Plasma shall not be held liable for any damages: indirect or consequential related to this product including loss of revenue. Furthermore, Harrick Plasma's liability shall not exceed the cost of the product. Operational instructions should be followed at all times.

WARRANTY

All products manufactured by Harrick Plasma come with a 1 year limited warranty. Any product failure that results from use in accordance with manufacturers guidelines is covered under the warranty. Any failure resulting from misuse of the product or resulting from actions such as dropping the unit or damage in poor storage conditions, for example, will not be repaired or replaced under warranty. Furthermore, products that have been intentionally damaged cannot be replaced or repaired under warranty. Products out of warranty or not subject to these conditions may be repaired by the manufacturer as a billed service at the manufacturer's discretion. With the exception of this exclusive warranty, Harrick Plasma makes no warranties, explicit or implied. We also disclaim any implied warranties of merchantability or fitness for a particular purpose.



WARRANTY INFORMATION

REPAIR RETURNS

Owners of products manufactured by Harrick Plasma in need of service or repair should contact Harrick Plasma prior to return of equipment, regardless of warranty coverage status. Products out of warranty may be repaired by the manufacturer as a billed service at the manufacturer's discretion. Any potentially hazardous substances must be removed from the plasma chamber and front cover interior if these items are to be returned with the product. Products to be repaired out of warranty will be initially evaluated and a formal repair estimate will be prepared for approval prior to any repairs being carried out. Any product returned for repair must be accompanied by a repair return document providing contact information, return shipping address and a description of product problems at issue and any measures taken.

NEW EQUIPMENT RETURNS

Recently purchased products manufactured by Harrick Plasma may be returned within 30 days of receipt. Products must be returned in unused, resalable condition, in original packing materials, and are subject to a 15% restocking fee. Vacuum pumps and accessories must be returned within 15 days of receipt in unused, resalable condition, in original packing materials, and are also subject to a 15% restocking fee. Purchasers wishing to return products should contact Harrick Plasma prior to returning.

FLOWRATE TABLE FOR PLASMAFLO FLOWMETER 1 (032-15)

- Flowmeters with a 65mm reference scale, rather than a direct-read scale, are provided to enable use with a broad range of gases.
- Use the flowrate table below for the specified process gas to convert the millimeter (mm) scale reading on Flowmeter 1 (032-15) to an actual flowrate (mL/min).
- Please note that Flowmeter 1 and Flowmeter 2 have different flow capacities. For flowrates for Flowmeter 2 (022-13), please see the next page.

To determine the flowrate:

- Read the position on the millimeter (mm) reference scale that corresponds to the center of the float. Read the float position with the float at eye level.
- Use the correlation table below to convert the float position (mm) to an actual flowrate (mL/min). For example, if argon (Ar) gas, metered at 10 psig regulated pressure, is inputted into Flowmeter 1 to raise the float to 35 mm on the reference scale, the corresponding Ar flowrate is 25 mL/min.
- The float position may deviate slightly after setting the flow level due to relaxation and equilibration of the flowmeter valve to its new position. Allow a few minutes for the flowrate to equilibrate and the pressure to stabilize.

Flowtube	032-15				
Float Material	Glass				
Gas Temperature	70 °F (21 °C)				
Gas Metering Pressure	Atmospheric pressure (0 psig) and 10 psig for Air; 10 psig for all other gases				
Take readings at the center of the float					
Scale Reading (mm)	Air 0 psig Flow (mL/min)	Air 10 psig Flow (mL/min)	Argon (Ar) 10 psig Flow (mL/min)	Nitrogen (N ₂) 10 psig Flow (mL/min)	Oxygen (O ₂) 10 psig Flow (mL/min)
65	48.7	77.1	67.3	72.3	71.7
60	43.8	68.3	58.3	66.3	63.5
55	38.1	59.0	50.9	60.0	54.8
50	32.7	51.5	43.4	51.5	47.0
45	27.9	44.8	37.4	43.7	40.3
40	22.9	38.9	31.5	35.0	34.2
35	19.0	30.7	25.0	28.6	27.0
30	15.5	25.7	20.4	23.1	22.5
25	12.6	20.4	16.6	18.3	18.3
20	9.94	16.2	13.2	13.2	14.1
15	7.27	12.3	9.5	9.7	10.6
10	5.41	9.2	7.3	6.3	7.9
5	3.66	5.7	4.1	4.1	5.1

FLOWRATE TABLE FOR PLASMAFLO FLOWMETER 2 (022-13)

- Flowmeters with a 65mm reference scale, rather than a direct-read scale, are provided to enable use with a broad range of gases.
- Use the flowrate table below for the specified process gas to convert the millimeter (mm) scale reading on Flowmeter 2 (022-13) to an actual flowrate (mL/min).
- Please note that Flowmeter 1 and Flowmeter 2 have different flow capacities. For flowrates for Flowmeter 1 (032-15), please see the previous page.

To determine the flowrate:

- Read the position on the millimeter (mm) reference scale that corresponds to the center of the float. Read the float position with the float at eye level.
- Use the correlation table below to convert the float position (mm) to an actual flowrate (mL/min). For example, if argon (Ar) gas, metered at 10 psig regulated pressure, is inputted into Flowmeter 2 to raise the float to 35 mm on the reference scale, the corresponding Ar flowrate is 57 mL/min.
- The float position may deviate slightly after setting the flow level due to relaxation and equilibration of the flowmeter valve to its new position. Allow a few minutes for the flowrate to equilibrate and the pressure to stabilize.

Flowtube	022-13				
Float Material	Glass				
Gas Temperature	70 °F (21 °C)				
Gas Metering Pressure	Atmospheric pressure (0 psig) and 10 psig for Air; 10 psig for all other gases				
Take readings at the center of the float					
Scale Reading (mm)	Air 0 psig Flow (mL/min)	Air 10 psig Flow (mL/min)	Argon (Ar) 10 psig Flow (mL/min)	Nitrogen (N ₂) 10 psig Flow (mL/min)	Oxygen (O ₂) 10 psig Flow (mL/min)
65	104	173.3	147.4	173.5	171.7
60	91.5	151.8	122.2	152.7	137.9
55	79.5	130.4	107.5	130.1	116.3
50	69.0	111.2	89.3	112.4	101.4
45	59.2	95.6	76.9	98.6	86.6
40	49.5	81.8	67.5	84.6	73.6
35	41.7	69.8	57.0	69.5	63.0
30	34.2	58.3	48.7	61.6	52.2
25	27.7	49.1	39.4	49.2	43.7
20	22.0	39.7	32.4	39.6	36.9
15	17.5	32.0	26.2	33.8	29.8
10	13.4	25.1	20.5	26.0	21.4
5	10.0	19.5	16.6	20.7	18.5

OPTIONAL AND REPLACEMENT PARTS

OPTIONAL PARTS

Premium Vacuum Pump, 230V	PDC-VP-2
Premium Vacuum Pump Oil	PDC-VP-OIL
Basic Vacuum Pump, 230V	PDC-VPE-2
Basic Vacuum Pump Oil	PDC-VPE-OIL
Fomblin-Based Vacuum Pump, 230V (for Oxygen Service)	PDC-OPF-2
Fomblin Fluid for Fomblin-Based Vacuum Pump.....	PDC-FMB
Dry Scroll Vacuum Pump, 230V (for Oxygen Service).....	PDC-OPD-2
PlasmaFlo, 230V	PDC-FMG-2
Quartz Plasma Chamber	PDC-00Q
Quartz Sample Tray (5.5" x 6.5").....	PDC-00T

REPLACEMENT PARTS

Pyrex Vacuum Chamber	PDC-191-420
Front Door O-ring, Viton	ORV-438
Inset Window O-ring, Viton	ORV-032
Window, Glass	001-505
Fluorescent Bulb	PDC-FLB

REPLACEMENT FUSES

PDC-002 (230V)

Plasma Cleaner	2 Amp, slow-blow (2)
PlasmaFlo	0.5 Amp, fast acting (2)

SPECIFICATIONS
PLASMA CLEANER (PDC-002)

Chamber Dimensions	6" diameter x 6.5" length
Chamber Material	Pyrex
Input Power	200 W
RF Frequency	MHz range
Inlet	1/8" NPT needle valve
Outlet	1/2" OD Pyrex tubing
Weight	45 lbs
Dimensions	11" H x 18" W x 9" D

POWER APPLIED TO RF COIL

Low Setting	7.2 W
Medium Setting	10.2 W
High Setting	29.6 W

OPTIONAL PLASMAFLO (PDC-FMG-2)

Vacuum Pressure Transducer	Thermocouple vacuum gauge
Pressure Reading	Digital meter
Pressure Range	1 to 1999 mTorr
Number of Gas Inputs	2
Flowmeter 1	65 mm reference scale; 49 mL/min maximum flowrate for atmospheric Air (0 psig) *
Flowmeter 2	65 mm reference scale; 104 mL/min maximum flowrate for atmospheric Air (0 psig) *
Flowmeter Accuracy	±2% of full scale
Flowmeter Maximum Operating Pressure / Temperature	200 psig / 250 °F (121 °C)
Gas Input Connection	1/4" Swagelok to 1/4" OD stainless steel hose adaptor
Gas Output Connection	1/4" Swagelok to 1/4" OD stainless steel hose adaptor
Output Connection to Plasma Cleaner	2-ft. length 1/4" ID flexible tubing with two (2) hose clamps
Weight	7 lbs
Dimensions	8.5" H x 10" W x 8" D

* Maximum flowrate varies with the process gas and regulated pressure. See *APPENDIX A* for flowrate tables for the most common process gases used with our Plasma Cleaner (Air, Ar, N₂, O₂). Flowrate tables with other process gases and regulated pressures can be made available.

SPECIFICATIONS

UTILITIES REQUIRED

Vacuum Pump minimum pumping speed of
1.4 m³/hr and an ultimate total
pressure of 200 mTorr or less

OPTIONAL VACUUM PUMPS

Premium Vacuum Pump (PDC-VP and PDC-VP-2)

Pumping speed 50/60 Hz 3.2/3.6 m³/hr
Ultimate total pressure (gas ballast closed) 1.5 mTorr
Ultimate total pressure (gas ballast open) 23 mTorr
Motor power 50/60 Hz 250/300 W
Weight 34 lbs
Dimensions 9" H x 15" W x 5" D

Basic Vacuum Pump (PDC-VPE and PDC-VPE-2)

Pumping speed 50/60 Hz 5.1 m³/hr
Ultimate total pressure (gas ballast closed) 7.5 mTorr
Ultimate total pressure (gas ballast open) 150 mTorr
Motor power 50/60 Hz 373 W
Weight 27 lbs
Dimensions 9.75" H x 14" W x 5.5" D

Fomblin-Based Vacuum Pump for Oxygen Service (PDC-OPF and PDC-OPF-2)

Pumping speed 50/60 Hz 3.3/3.9 m³/hr
Ultimate total pressure (gas ballast closed) 1.5 mTorr
Ultimate total pressure (gas ballast open) 90 mTorr
Motor power 50/60 Hz 250/300 W
Weight 48 lbs
Dimensions 9" H x 17" W x 6.5" D

Dry Scroll Vacuum Pump for Oxygen Service (PDC-OPD and PDC-OPD-2)

Pumping speed 50/60 Hz 4.8/6 m³/hr
Ultimate total pressure (gas ballast closed; 50/60 Hz) 53/45 mTorr
Ultimate total pressure (gas ballast open; 50/60 Hz) 263/225 mTorr
Motor power 50/60 Hz 250/300 W
Weight 51 lbs
Dimensions 11.5" H x 17" W x 10" D



Manual Part No. PDC002CE-M-10

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